7. DENDROKRONOLOŠKE RAZISKAVE NA KOLIŠČARSKIH NASELBINAH STARE GMAJNE IN BLATNA BREZOVICA

Katarina ČUFAR, Anton VELUŠČEK, Tjaša TOLAR & Bernd KROMER

Izvleček

Predstavljeni so rezultati dendrokronoloških in radiometričnih raziskav na koliščarskih naselbinah Stare gmajne in Blatna Brezovica na Ljubljanskem barju.

Koliščarski naselbini sta obstajali okoli leta 3100 pr. Kr. Raziskava je tudi pokazala, da sta bili poseljeni v približno istem obdobju oz. da je Blatna Brezovica najverejtneje nekoliko mlajša.

Ključne besede: dendrokronologija, radiokarbonsko datiranje, Stare gmajne, Blatna Brezovica, Ljubljansko barje, eneolitik.

7.1 STARE GMAJNE

Koliščarska naselbina Stare gmajne leži na jugozahodnem delu Ljubljanskega barja v bližini Ljubljanice nasproti osamelca Blatna Brezovica.

V primerjavi z drugimi kolišči Ljubljanskega barja so bile Stare gmajne odkrite relativno pozno, šele leta 1992. Leta 1995 so na najdišču potekale prve arheološke terenske raziskave, vzorci lesa za dendrokronološke raziskave na Starih gmajnah pa so bili odvzeti v štirih etapah med letoma 2002 in 2007.[1]

7.1.1 DENDROKRONOLOŠKE RAZISKAVE

7.1.1.1 VZORČENJE LESA

Iz načrta (*sl. 7.1*) je razvidno, da so bili koli vzeti iz osmih jarkov, povprečno širokih približno 1 m, in iz treh sond. Tako je ekipa Inštituta za arheologijo ZRC SAZU

[1] Glej poglavje 3 v tem zborniku.

7. DENDROCHRONOLOGICAL RESEARCH AT THE PILE-DWELLING SETTLEMENTS STARE GMAJNE AND BLATNA BREZOVICA

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Abstract

We present the results of dendrochronological and radiometric researches on the pile-dwelling settlements Stare gmajne and Blatna Brezovica, both located at the Ljubljansko barje.

The pile-dwelling settlements date to c. 3100 BC. The research has also showed that they were contemporary or that Blatna Brezovica existed somewhat later.

Keywords: dendrochronology, radiocarbon dating, Stare gmajne, Blatna Brezovica, the Ljubljansko barje, Eneolithic.

7.1 STARE GMAJNE

The pile-dwelling settlement Stare gmajne is located on the south-western part of the Ljubljansko barje, near the Ljubljanica and opposite to the isolated hill Blatna Brezovica.

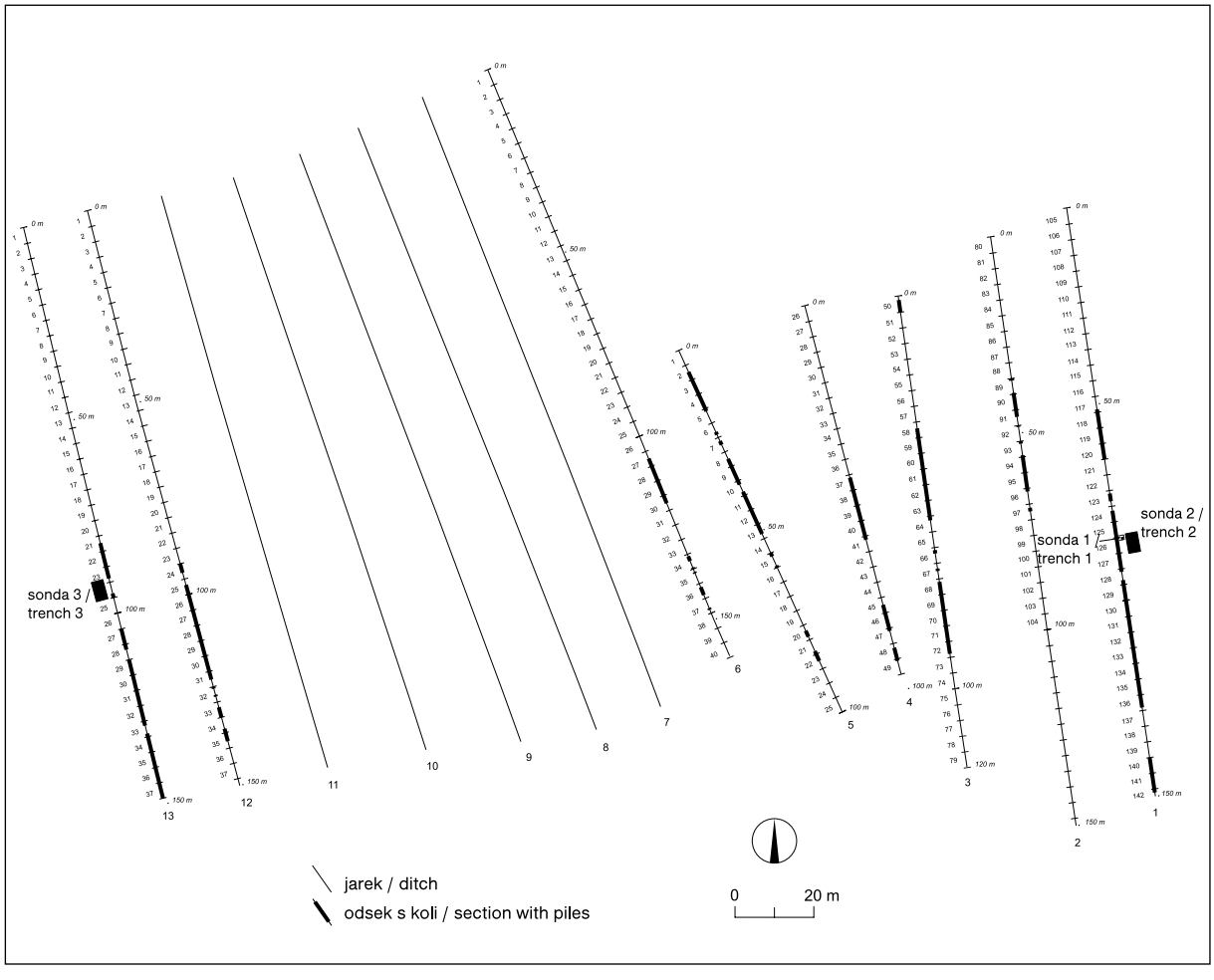
Stare gmajne was discovered in 1992, which is relatively late in comparison to other pile-dwellings of the Ljubljansko barje. The first archaeological field researches were carried out in 1995. Samples of wood for dendrochronological research were collected in four stages, between 2002 and 2007.[1]

7.1.1 DENDROCHRONOLOGICAL RESEARCHES

7.1.1.1 WOOD SAMPLING

As seen on the plan (*Fig. 7.1*), piles were collected from eight ditches with an average width of c. 1 m, and

[1] See Chapter 3 in this monograph.



Sl. 7.1: Načrt kolišča Stare gmajne z označenimi sondami, jarki, odseki in območji z lesenimi predmeti (koli, drevaka 1 in 2 ter kolo z osjo). Risba: T. Korošec.
Fig. 7.1: Plan of the pile-dwelling Stare gmajne with marked trenches, ditches, sections/or sectors and areas, where wooden objects were found (piles, logboats 1 and 2 and a wheel with an axle). Drawn by: T. Korošec.

leta 2002 odvzela vzorce v odvodnih jarkih 1 do 5 in v sondi 1, leta 2004 v odvodnih jarkih 6, 12 in 13, leta 2006 v sondi 2 in leta 2007 v sondi 3. Posamezni jarki so bili razdeljeni na štirimetrske odseke. Sonda 1 je bila zastavljena vzhodno od jarka 1 med odsekoma 125 in 126 in je obsegala približno 1,6 m^2 (1,4 × 1,15 m); sonda 2 je bila zastavljena v bližini sonde 1 in je merila 15 m^2 (3 × 5 m); sonda 3, ki je prav tako obsegala 15 m^2 (3 × 5 m), pa je bila zastavljena na skrajni severozahodni strani koliščarske naselbine, zahodno od odvodnega jarka 13 v bližini odsekov 23 in 24. V odvodnih jarkih od 7 do 11 ter 14 in 15, ki se raztezata zahodno od jarka 13 in na *sl. 7.1* nista predstavljena, ni bilo kolov in arheoloških najdb.

Na Starih gmajnah je bilo v štirih sezonah analiziranih 932 in identificiranih 925 vzorcev lesa (*tab. 7.1*). Arheološki les je tako kot pri drugih koliščarskih naselbinah na Ljubljanskem barju večinoma ostanek navpičnih kolov, ki so jih koliščarji zabili v tla in na njih postavili bivališča, s tem da smo na Starih gmajnah naleteli tudi na izjemne najdbe, kot so leseno kolo in os ter dva drevaka, ki so bile

from three trenches. In 2002, a team from the the Institute of Archaeology of the Scientific Research Centre of the Slovenian Academy of Sciences and Arts (ZRC SAZU), took samples from irrigation ditches 1 to 5 and in trench 1. In 2004, they took samples from irrigation ditches 6, 12 and 13, in 2006 from trench 2 and in 2007 from trench 3. Individual ditches were divided into four metres long sections. Trench 1 was opened eastwards from ditch 1, between sections 125 and 126, and it measured c. 1.6 m^2 (1.4 × 1.15 m); trench 2 was opened near trench 1 and measured 15 m^2 (3 × 5 m); trench 3, also measuring 15 m^2 (3 × 5 m), was opened on the northwestern side of the pile-dwelling settlement, to the west from the irrigation ditch 13, near sections 23 and 24. In irrigation ditches 7 to 11 and 14 and 15, which are located westwards from ditch 13 and are not drawn on *Fig. 7.1*, no piles or archaeological finds have been found.

During four stages of work at Stare gmajne, we analysed 932 and identified 925 samples of wood (*Tab. 7.1*). Archaeological wood is, as at other pile-dwelling

Tab. 7.1: Analizirani vzorci arheološkega lesa s Starih gmajn.
Tab. 7.1: Analysed samples of archaeological wood from Stare gmajne.

Vrsta lesa **Wood species**	**Število vzorcev** **Number of samples**	**Delež (%) *** **Share (%) ***	**Število navpičnih kolov** **Number of vertical piles**	**Delež (%) **** **Share (%) ****
Abies alba	5	1	5	1
Acer sp.	31	3	27	3
Alnus glutinosa	31	3	28	3
Corylus avellana	9	1	5	1
Carpinus betulus	3	> 0	3	> 0
Fagus sylvatica	32	3	31	3
Fraxinus sp.	409	44	405	45
Populus sp.	51	5	48	5
Quercus sp.	334	36	327	36
Salix sp.	20	2	20	2
Neidentificirano / Unidentified	7	1	7	1
SKUPAJ TOTAL	**932**	**100**	**906**	**100**

* Delež, preračunan glede na vse vzorce. / Share calculated for the entire sample population.
** Delež, preračunan glede na vse navpične kole. / Share calculated for the subsample of vertical piles.

primerne za dendrokronološko analizo in so predstavljene posebej v poglavjih 8 in 9 v tem zborniku.

7.1.1.2 PRIPRAVA IN IDENTIFIKACIJA LESA

Za dendrokronološke raziskave je bil odvzet les vseh ohranjenih elementov ne glede na obliko, premer in lesno vrsto. Najdbam lesa smo najprej izmerili natančne koordinate in nato odžagali 10–20 cm dolg kos, ki smo ga takoj po odvzemu izmerili, označili z identifikacijsko številko in ga zalitega z vodo shranili v nepredušno zaprti polietilenski vrečki.

Zbrane vzorce smo odpeljali na Oddelek za lesarstvo, kjer smo jih obdelali z mizarskimi stroji. V nadaljevanju smo vsak vzorec globoko zamrznili in zamrznjenemu zgladili površino ter ga pregledali pod stereomikroskopom in mu prešteli branike. Lesno vrsto smo pri hrastu ali jesenu določili z opazovanjem pod stereomikroskopom, za preostale vrste pa smo naredili tanke preparate za mikroskopsko identifikacijo lesa.

Najpogostejša lesna vrsta na kolišču je bil jesen, ki je zastopan kar s 44 % vzorcev, sledil mu je hrast s 36 % vzorcev (*tab. 7.1*). Petina vzorcev je pripadala drugim vrstam, med katerimi so prevladovali koli iz lesa topolov (*Populus*), bukve (*Fagus*), jelše (*Alnus*) in javorja (*Acer*). Manjše število vzorcev (pod 1 %) je bilo preveč uničenih, da bi lahko določili njihovo lesno vrsto.

Med navpičnimi koli so z več kot 60 % prevladovali tisti s premerom od 6 do 12 cm. Približno 20 % jih je imelo premer od 12,5 do 22 cm, manj kot 10 % pa premer od 23 do 40 cm ali pod 6 cm. Koli večjih premerov so bili praviloma klani.

settlements at the Ljubljansko barje, mostly presented by the remains of vertical piles, which were driven into the ground as building foundations. Moreover, we came across some exceptional finds at Stare gmajne, such as a wooden wheel with an axle and two logboats. These were suitable for dendrochronological analysis and are discussed in chapters 8 and 9.

7.1.1.2 THE PREPARATION AND IDENTIFICATION OF WOOD

Wood for dendrochronological researches was taken from all preserved elements, regardless of form, diameter and wood species. We first measured accurate coordinates of all wooden finds and then sawed off 10–20 cm long piece, measured it immediately after sawing, marked it with an identification number and stored in a hermetically closed polyethylene bag, filled with water.

The samples were taken to the Department of Wood Science and Technology, where they were prepared using carpentry equipment. Each sample was then deep-frozen, its surface was smoothened and inspected under a stereo microscope to count the annual rings. Oak and ash wood species were determined with observation under stereo microscope. To determine other species, we made thin slides of samples and identified the wood species microscopically.

The most common wood species on the pile-dwelling, with 44 % of samples, was ash. Oak followed with 36 % of samples (*Tab. 7.1*). One fifth of the samples belonged to other species, with poplar (*Populus*), beech

Tab. 7.2: Število vzorcev po vrstah lesa ter število in deleži dendrokronloško merjenih in sinhroniziranih (relativno datiranih) vzorcev.
Tab. 7.2: Number of samples according to wood species and percent of dendrochronologically measured and cross-dated samples.

Vrsta lesa Wood species	Število Number	Merjen (št.) Measured (no.)	Merjen (%)* Measured (%)*	Sinhroniziran (št.) Cross-dated (no.)	Sinhroniziran (%)* Cross-dated (%)*
Abies alba	5	0			
Acer sp.	31	0			
Alnus glutinosa	31	0			
Corylus avellana	9	0			
Carpinus betulus	3	0			
Fagus sylvatica	32	0			
Fraxinus sp.	409	115	12	34	4
Populus sp.	51	0			
Quercus sp.	334	193	21	124	13
Salix sp.	20	0			
Neidentificirano / Unidentified	7	0			
SKUPAJ TOTAL	**932**	**308**	**33**	**158**	**17**

* Delež, preračunan glede na vse vzorce. / Share calculated for the entire sample population.

Dendrokronološke meritve smo opravili samo na vzorcih hrasta in jesena, ki so imeli vsaj 45 branik. Po tem kriteriju je bilo za merjenje širin branik primernih le 33 % vzorcev, uspešno pa smo sinhronizirali oz. relativno datirali le 17 % vzorcev (*tab. 7.2*).

7.1.1.3 MERJENJE

Postopek merjenja širin branik smo izvedli na gladko obdelanih vzorcih s pomočjo pomične mizice, stereomikroskopa in programa TSAP/X. Rezultate meritev smo grafično prikazali kot zaporedje širin branik v odvisnosti od časa. Na vsakem vzorcu smo širine branik izmerili vzdolž dveh radijev. Meritve na vsakem vzorcu smo preverili in jih združili v povprečje, ki smo ga uporabili za nadaljnje primerjave (sinhroniziranje) grafov različnih vzorcev.[2]

Vsa zaporedja, ki so izkazovala optično in statistično značilno ujemanje, smo združili v plavajoče nedatirane kronologije, ločeno za jesen in hrast. Sestavili smo dve jesenovi in eno hrastovo kronologijo.

7.1.2 REZULTATI

7.1.2.1 HRASTOVA KRONOLOGIJA SG-QUSP1

Na kolišču so dobro tretjino lesa predstavljali hrastovi vzorci, ki jih je bilo 334 (*tab. 7.1*). Od teh jih je bilo po naših kriterijih skoraj 60 % (193) primernih za dendrokronološke meritve.

[2] Glej npr. Čufar, Levanič 1998.

(*Fagus*), alder (*Alnus*) and maple (*Acer*) prevailing. A smaller amount of samples (under 1 %) was not preserved enough to identify wood species.

Over 60 % of vertical piles had a diameter of 6–12 cm. Around 20 % had a diameter of 12.5–22 cm and less than 10 % had a diameter from 23–40 cm or under 6 cm. Piles with larger diameters were generally cleaved.

Dendrochronological measurements were only done on oak and ash samples with at least 45 annual rings. According to this criterion, only 33 % of samples were suitable for tree-ring widths measurement, and only 17 % of samples were successfully cross-dated (*Tab. 7.2*).

7.1.1.3 MEASURING

Procedure of measuring of tree-ring widths was carried out on smoothened samples. To measure tree-ring widths, we used LINTAB measuring device, a stereo microscope and a TSAP/X program. Results of measurements were shown graphically as a sequence of tree-ring widths vs. time. Tree-ring widths were measured along two radii on each sample. The two tree-ring series of each sample were then checked and united into an average that we used for further comparisons (cross-dating) with tree-ring series of different samples.[2]

All sequences that matched visually and statistically, were combined into floating undated tree-ring chronologies, made separately for ash and oak. We constructed two ash- and one oak chronology.

[2] See e.g. Čufar, Levanič 1998.

Približno tretjina hrastovih kolov je bila narejena iz celotnih debel manjših dreves, približno dve tretjini pa iz vzdolžno razklanih večjih debel, s premeri nad 15 cm.

Hrastovi koli so bili v glavnem enakomerno razporejeni po celotnem najdišču; sorazmerno najmanj jih je bilo v jarkih 6 in 5 (*sl. 7.4*). Čeprav so se hrastovi vzorci med seboj razlikovali po številu branik in rastnih posebnostih smo jih 124 relativno datirali (*tab. 7.2*). Številke relativno datiranih kolov so:

SG02-3, 5, 14, 29, 38, 39, 43, 52, 53, 58, 67, 91, 98, 102, 107, 110, 112, 116, 117, 122, 126, 128, 145, 165, 200, 203, 206, 210, 214, 219, 225, 234, 236, 237, 249, 252, 257, 259, 261, 262, 266, 268, 269, 270, 271, 274, 275, 278, 279, 282, 284, 287, 292, 295, 299, 301, 308, 324, 325, 326, 346, 378, 381, 392, 393, 402, 403, 406, 409, 420, 424, 425, 427, 428, 433, 435, 441, 443, 451, 452, 461, 467, 471, 475, 477, 480, 482, 487, 488, 489, 492, 496, 499, 512, 520 in 528.

SG04-597, 606, 611, 615, 692, 701, 702, 704, 745, 747, 769, 770, 804 in 806.

SG06-838, 839, 841, 846, 847, 849, 850, 853, 854, 855, 856 in 974.

SG07-1041 in 1054.

Večina zaporedij ni izkazovala rastnih anomalij, zato smo vse razen **SG04-**701, 702, 745, 747, **SG07-**1041 in 1054 združili v kronologijo SG-QUSP1 s solidno pokritostjo in dobrim ujemanjem širin branik na mlajšem delu, dolgem približno 115 let (*sl. 7.2*). Pri mnogih vzorcih sta bili ohranjeni skorja in zadnja branika, kar nam je omogočilo, da smo zabeležili nekaj jasnih faz gradbenih aktivnosti na kolišču, ko so v kratkem časovnem obdobju (eno leto do nekaj let) posekali večje število dreves.

Tudi relativno datirani hrastovi koli so razporejeni po celotnem kolišču, večino pa smo našli v vzhodnem delu, medtem ko so na zahodnem delu manj številni (prim. *sl. 7.8*).

7.1.2 RESULTS

7.1.2.1 THE SG-QUSP1 OAK CHRONOLOGY

Oak samples represented more than one third of wood on the pile-dwelling; i.e. 334 samples (*Tab. 7.1*). Almost 60 % (193) of them were suitable for dendrochronological measurements, according to our criteria.

Around one third of oak piles were made of entire trunks of smaller trees and around two thirds from longitudinally cleaved larger trunks, with diameters over 15 cm.

Oak piles were more or less evenly spread over the entire excavation site; a smaller amount of them is only seen in ditches 6 and 5 (*Fig. 7.4*). Although oak samples differentiated to one another according to amount of annual rings and growth anomalies, we relatively dated 124 of them (*Tab. 7.2*). Relatively dated piles are as follows:

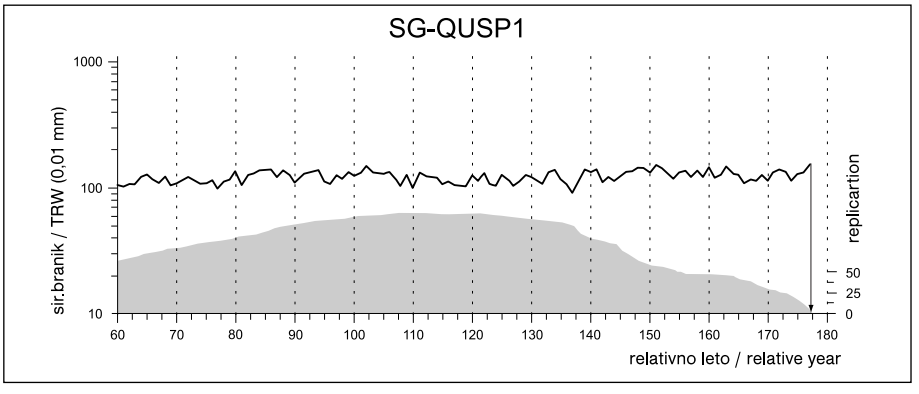
SG02-3, 5, 14, 29, 38, 39, 43, 52, 53, 58, 67, 91, 98, 102, 107, 110, 112, 116, 117, 122, 126, 128, 145, 165, 200, 203, 206, 210, 214, 219, 225, 234, 236, 237, 249, 252, 257, 259, 261, 262, 266, 268, 269, 270, 271, 274, 275, 278, 279, 282, 284, 287, 292, 295, 299, 301, 308, 324, 325, 326, 346, 378, 381, 392, 393, 402, 403, 406, 409, 420, 424, 425, 427, 428, 433, 435, 441, 443, 451, 452, 461, 467, 471, 475, 477, 480, 482, 487, 488, 489, 492, 496, 499, 512, 520 and 528.

SG04-597, 606, 611, 615, 692, 701, 702, 704, 745, 747, 769, 770, 804 and 806.

SG06-838, 839, 841, 846, 847, 849, 850, 853, 854, 855, 856 and 974.

SG07-1041 and 1054.

Most of tree-ring series were not showing any growth anomalies. That is why all, except for **SG04-**701, 702, 745, 747, **SG07-**1041 and in 1054, were incorporated to the SG-QUSP1 tree-ring chronology with well replicated c.



Sl. 7.2: Hrastova kronologija SG-QUSP1: zadnjih 117 let kronologije z dobrim pokritjem in dobrim ujemanjem širin branik. Zadnja branika (puščica, relativni datum 177) je radiokarbonsko datirana v leto 3109 ± 12 pr. Kr. (razpon 3121–3095, 2σ, 95,4 % verjetnost). TRW – širina branik; pokritost.

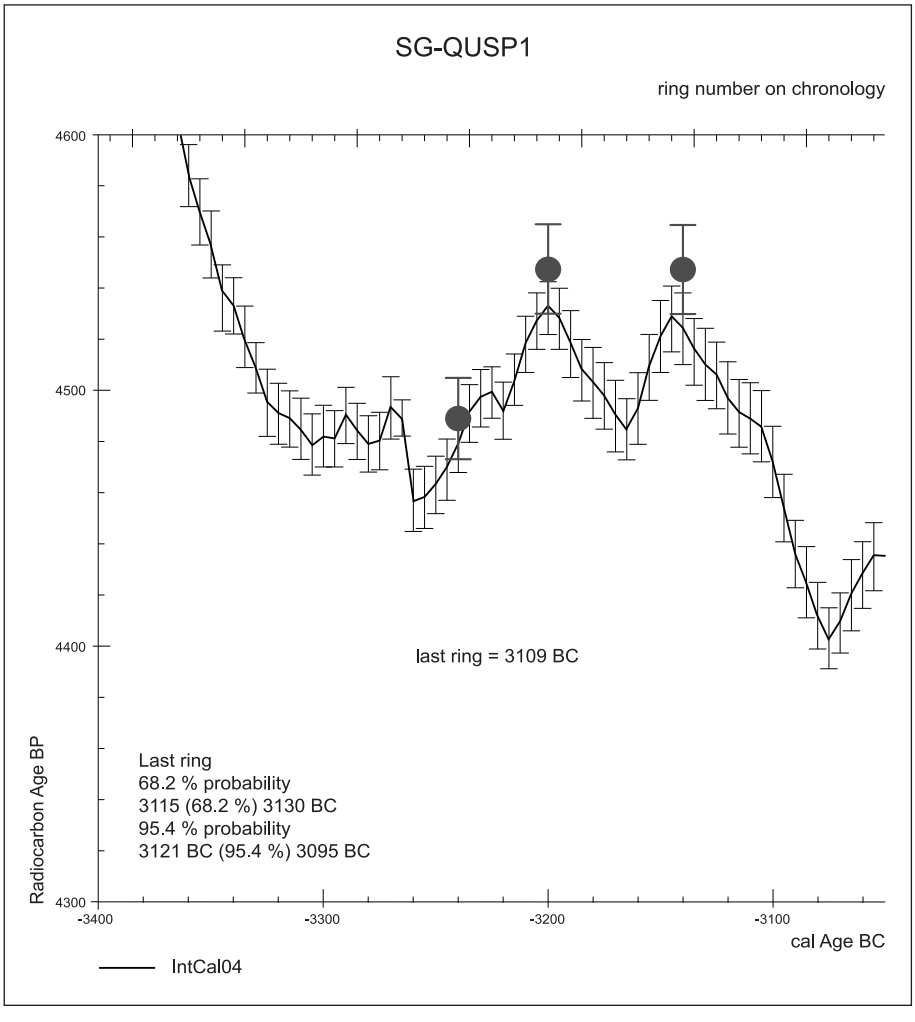
Fig. 7.2: The SG-QUSP1 oak chronology – the last 117 years of chronology is well replicated. The last annual ring (arrow, relative date 177) is radiocarbon dated to 3109 ± 12 BC (span 3121–3095, 2σ, 95.4 % probability). TRW – tree-ring widths; replication.

Tab. 7.3: Radiokarbonske datacije vzorcev iz hrastove kronologije SG-QUSP1 (konec v relativnem letu 177). Datiranje je bilo opravljeno v laboratoriju na Heidelberger Akademie der Wissenschaften, Radiometrische Altersbestimmung von Wasser und Sedimenten in v ETH Zürich.
Tab. 7.3: Radiocarbon dates of samples from the SG-QUSP1 oak chronology (end in relative year 177). Dating was performed in the laboratory of the Heidelberger Akademie der Wissenschaften, Radiometrische Altersbestimmung von Wasser und Sedimenten, and at the ETH Zürich.

Kol št. Pile no.	Lab. št. Lab. no.	Drevesna vrsta Wood species	Število branik Number of tree rings	Srednja branika Mid tree ring	^{14}C-age BP
SG02-406	Hd-22911	*Quercus* sp.	20	45	4489 ± 16
SG02-499	Hd-27938	*Quercus* sp.	30	85	4589 ± 26
SG02-441	Hd-22385	*Quercus* sp.	20	145	4547 ± 17

Za kronologijo smo pridobili tri radiokarbonske datume, z metodo "wiggle-matching" pa smo zadnjo braniko kronologije datirali v leto 3109 ± 12 pr. Kr. (razpon 3121–3095, 2σ, 95,4 % verjetnost) (*tab. 7.3* in *7.4*; *sl. 7.3*).

115 years long younger part (*Fig. 7.2*). Many samples had preserved bark and the last annual ring, which enabled us to reconstruct some clear phases of building activities on the pile-dwelling, when they felled large amount of trees in a short time period (one year to a few years).



Sl. 7.3: Absolutno datiranje kronologije Starih gmajn SG-QUSP1 z uporabo opcije "sequence" programa OxCal 3.5.
Fig. 7.3: Absolute dating of the Stare gmajne SG-QUSP1 chronology using the "sequence" option of the OxCal 3.5 program.

Tab. 7.4: Radiokarbonska datacija vzorca SG04-745, ki je sinhroniziran s kronologijama Spodnjega mostišča SM2-QUSP3 in VMO-QUSP1. Datiranje je bilo opravljeno v laboratoriju na Heidelberger Akademie der Wissenschaften, Radiometrische Altersbestimmung von Wasser und Sedimenten.
Tab. 7.4: Radiocarbon dated sample SG04-745, which is cross-dated with the Spodnje mostišče SM2-QUSP3 and VMO-QUSP1 chronologies. Dating was performed in the laboratory at the Heidelberger Akademie der Wissenschaften, Radiometrische Altersbestimmung von Wasser und Sedimenten.

Kol št. Pile no.	Lab. št. Lab. no.	Drevesna vrsta Wood species	Število branik Number of tree rings	Srednja branika Mid tree ring	^{14}C-age BP
SG04-745	Hd-27697	*Quercus* sp.	20	304	4552 ± 22

Zadnji datumi vzorcev lesa nakazujejo pomembnejše gradbene aktivnosti na kolišču, ki so trajale več kot 50 let, to je približno od leta od 3160 do 3109 pr. Kr.

Skupino vzorcev, ki smo jih medsebojno sinhronizirali, smo izkopali iz jarkov 12 in 13 oz. sonde 3 (številke: **SG04-**701, 702, 745, 747; **SG07-**1041, 1054). Sinhronizirali smo jih s kronologijama Spodnjega mostišča SM2-QUSP3 in VMO-QUSP1,[3] ki konec gradbenih aktivnosti na njem postavljata v obdobje okoli leta 3351 pr. Kr. To nakazuje, da so bile nekatere konstrukcije na zahodnem delu naselbine Stare gmajne verjetno postavljene približno 20 let po koncu dokumentiranih gradbenih aktivnosti na Spodnjem mostišču (kronologija VMO-QUSP1), to je okoli leta 3330 pr. Kr.[4] To smo ugotovili s pomočjo radiokarbonskega datiranja vzorca SG04-745 (*tab. 7.4*), 7 vzorcev s koliščarske naselbine Spodnje mostišče in uporabo metode "wiggle-matching".[5]

Vse to nakazuje, da je na območju Starih gmajn pred intenzivno poselitvijo večje površine (jarki 1–6 in 12, 13, sondi 1 in 2), ki je trajala več kot 50 let in se je končala v času okoli leta 3109 pr. Kr., obstajala približno od 170 do 220 let starejša, prostorsko omejena naselbina.

Na drugi strani se mlajši radiokarbonski datirani vzorci s Starih gmajn časovno ujemajo tudi z radiokarbonsko datiranim lesom s kolišča Blatna Brezovica, kjer je naša ekipa leta 2003 opravila sondiranje, dendrokronološke raziskave in radiokarbonsko datiranje na predhodno že raziskanem kolišču.[6] Koliščarska naselbina Veliki Otavnik Ib, kjer so bili vzorci lesa odvzeti in raziskani v letih 2006 in 2007, pa izkazuje eno samo fazo gradbenih aktivnosti, ki so se končale praktično sočasno kot najmlajša naselbinska faza na Starih gmajnah.[7]

7.1.2.2 JESENOVI KRONOLOGIJI SG-FRSP1 IN SG-FRSP2

Jesen je bil prevladujoča lesna vrsta s 409 vzorci, kar je skoraj polovica (44 %) vseh analiziranih vzorcev

Furthermore, cross-dated oak piles spread over the entire pile-dwelling, with the majority in the eastern part, while less of them have been found in the western part (e.g. *Fig. 7.8*).

We obtained three radiocarbon dates for chronology, and established a relative date end of 3109 ± 12 BC (span 3121–3095, 2σ, 95.4 % probability) with the "wiggle-matching" procedure of OxCal (*Tabs. 7.3* and *7.4*; *Fig. 7.3*).

The last dates of wood samples remit building activities at the pile-dwelling, which lasted over 50 years; from c. 3160 to 3109 BC.

Group of samples, that were cross-dated, was dug in ditches 12 and 13 and in trench 3 (numbers: **SG04-**701, 702, 745, 747; **SG07-**1041, 1054). These samples were cross-dated with the Spodnje mostišče SM2-QUSP3 and VMO-QUSP1 chronologies,[3] which denote the end of building activities at Spodnje mostišče in c. 3351 BC. This indicates that some constructions on the western part of the settlement Stare gmajne, were perhaps built c. 20 years after the conclusion of documented building activities at Spodnje mostišče (VMO-QUSP1 chronology); in c. 3330 BC.[4] We discovered this with the help of radiocarbon dating of sample SG04-745 (*Tab. 7.4*), 7 samples from pile-dwelling settlement Spodnje mostišče and the use of the "wiggle-matching" procedure.[5]

The above indicates that, apart from an intense settling of larger surface (ditches 1–6 and 12, 13, trenches 1 and 2), which lasted over 50 years and finished in c. 3109 BC, also a c. 170 to 220 years earlier, spatially limited settlement existed at Stare gmajne.

On the other hand, later radiocarbon dated samples from Stare gmajne match with radiocarbon dated wood from the pile-dwelling Blatna Brezovica, where our team carried out sample trenching, dendrochronological researches and radiocarbon dating in 2003, on preliminarily already investigated pile-dwelling.[6] Pile-dwelling settlement Veliki Otavnik Ib, where samples of wood were taken and investigated in 2006 and 2007, shows a single

[3] Prim. Velušček, Čufar 2002.
[4] Čufar et al., v pripravi.
[5] Čufar, Kromer, neobjavljeno.
[6] Glej poglavji 5 in 7.2 v tem zborniku.
[7] Glej poglavje 6 v tem zborniku.

[3] E.g. Velušček, Čufar 2002.
[4] Čufar et al., in prep.
[5] Čufar, Kromer, unpublished.
[6] See Chapters 5 and 7.2 in this monograph.

Tab. 7.5: Radiokarbonska datacija vzorca iz jesenove kronologije SG-FRSP1. Datiranje je bilo opravljeno v laboratoriju Heidelberger Akademie der Wissenschaften, Radiometrische Altersbestimmung von Wasser und Sedimenten.
Tab. 7.5: Radiocarbon date of sample from the SG-FRSP1 ash chronology. Dating was performed in the laboratory of the Heidelberger Akademie der Wissenschaften, Radiometrische Altersbestimmung von Wasser und Sedimenten.

Kol št. Pile no.	Lab. št. Lab. no.	Drevesna vrsta Wood species	Število branik Number of tree rings	^{14}C-age BP
SG02-6	Hd-24026	*Fraxinus excelsior*	40	4484 ± 19

(*tab. 7.1*). Jesenovi koli se pojavljajo v vseh jarkih, s tem da jih je na zahodu naselbine v jarkih 12 in 13 ter v sondi 3 malo. Njihova značilnost so majhni premeri in majhno število branik, zato jih je bilo po našem kriteriju za dendrokronološke meritve primernih le 115 (*tab. 7.2*). Najprej smo sinhronizirali oz. relativno datirali 34 vzorcev in jih 22 vključili v kronologijo SG-FRSP1 in 12 v kronologijo SG-FRSP2. Pri večini vzorcev iz obeh kronologij je bila skorja ohranjena.

V jesenovo kronologijo SG-FRSP1 so vključeni vzorci, ki smo jih pridobili leta 2002 (**SG02-**1, 2, 6, 8, 9, 11, 12, 13, 66, 87, 150, 196, 232, 290, 348, 447, 478, 481, 491, 522, 532, 539) in so bili predvsem v jarkih 1 in 5, ter posamezni koli v jarkih 3 in 4. Ker je ta kronologija dokaj kratka, smo le na osnovi radiokarbonskega datuma vzorca kola SG02-6 (*tab. 7.5*) in s pomočjo primerjave dendrokronoloških grafov ocenili, da gradbene aktivnosti v okviru omenjene kronologije sovpadajo s koncem kronologije SG-QUSP1 ali pa predstavljajo še nekoliko mlajši del kolišča, ki je nastalo do okoli 3100 pr. Kr.

Do druge jesenove kronologije smo prišli na podlagi lesa, ki je bil dokumentiran leta 2007 pri izkopavanju v sondi 3. Šest merjenih vzorcev (**SG07-**1045, 1047, 1049, 1056, 1058, 1064) iz leta 2007 smo medsebojno sinhronizirali in sestavili kronologijo SG-FRSP2, na katero so se nato sinhronizirali vzorci drugih raziskovalnih let, tako da jo sestavlja skupno 12 vzorcev lesa. Vzorci se pojavljajo v sondi 3 in jarku 13 na skrajnem zahodu naselbine ter v jarkih 1, 3, 4, in 5 na vzhodu.

Kronologija SG-FRSP2 ni radiokarbonsko datirana, vendar smo jo sinhronizirali s hrastovo kronologijo SG-QUSP1 (relativni datum desno 175, OVL 119, t_{BP} 4,8, GLK 61*), kar nakazuje, da so zgoraj naštete jesenove pilote vgradili verjetno sočasno s hrastovimi proti koncu gradbenih aktivnosti v okviru kronologije SG-QUSP1 okoli leta 3111 pr. Kr.

7.1.2.3 IZBOR GRADBENEGA LESA IN GRADBENE AKTIVNOSTI

Kot je bilo omenjeno v uvodnem delu, so koliščarji s Starih gmajn za nosilne gradbene kole uporabljali različne vrste lesa. Največ je bilo lesa jesena (*Fraxinus* sp.) in hrasta (*Quercus* sp.), uporabljali pa so tudi les topola (*Populus* sp.), bukve (*Fagus sylvatica*), jelše (*Al-*

phase of building activity, which ended simultaneously with the latest settlement phase of Stare gmajne.[7]

7.1.2.2 SG-FRSP1 AND SG-FRSP2 ASH CHRONOLOGIES

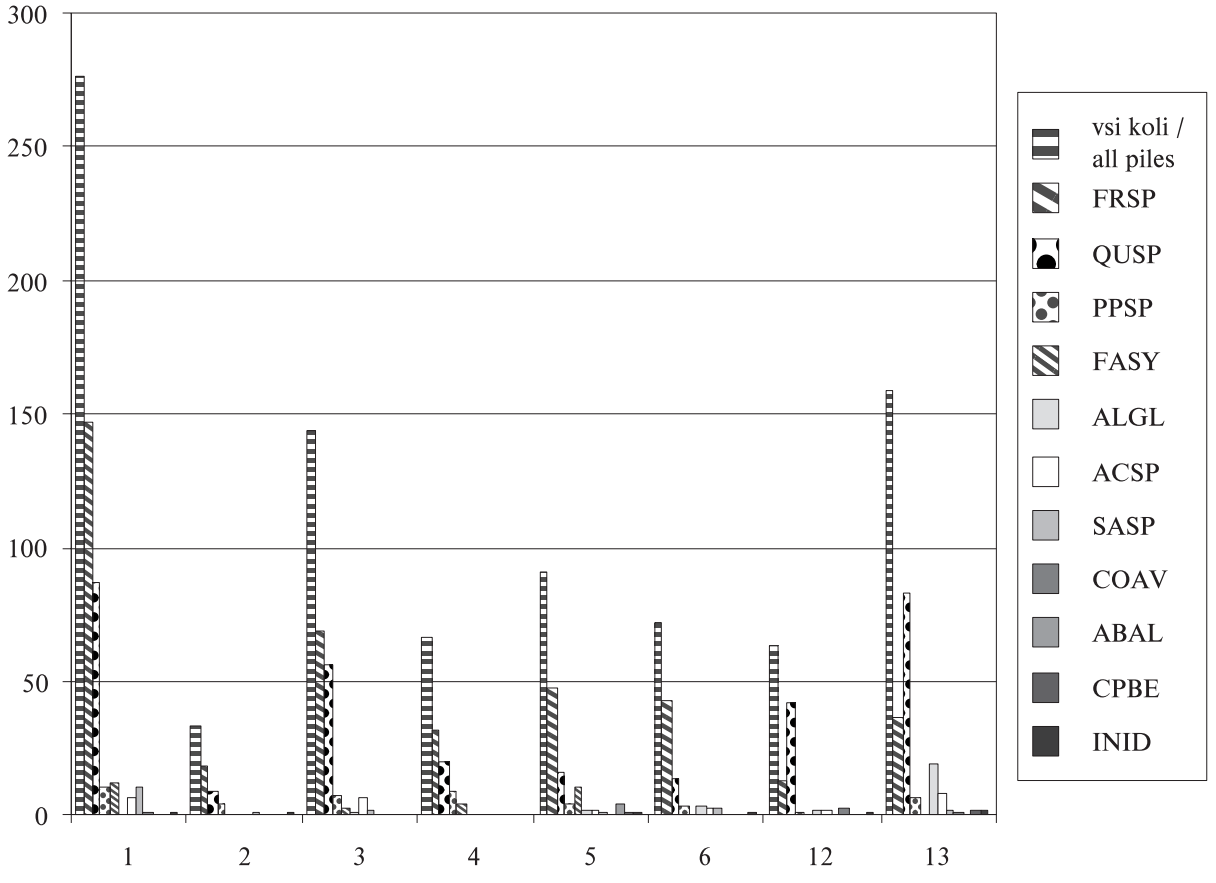
Ash was a dominant wood species with 409 samples, which is almost half (44 %) of all analysed samples (*Tab. 7.1*). Ash piles were present in all ditches. However, less of them occur on the western part of the settlement in ditches 12 and 13 and in trench 3. Their characteristics are small diameters and small number of annual rings. That is why, considering our criteria, only 115 of them were suitable for dendrochronological measurement (*Tab. 7.2*). We first cross-dated or relatively dated 34 samples. 22 of them were incorporated into the SG-FRSP1 chronology and 12 into the SG-FRSP2 chronology. Bark was preserved at most samples from both chronologies.

Samples, taken in 2002 (**SG02-**1, 2, 6, 8, 9, 11, 12, 13, 66, 87, 150, 196, 232, 290, 348, 447, 478, 481, 491, 522, 532, 539), are included in the SG-FRSP1 ash chronology. They were found mainly in ditches 1 and 5 and as individual piles in ditches 3 and 4. As the chronology is rather short, we evaluated period of building activity only based on a radiocarbon date of the sample pile SG02-6 (*Tab. 7.5*) from the mentioned chronology and with the comparison of dendrochronological diagrams. Namely, building activities are contemporary with the end of the SG-QUSP1 chronology or they indicate an even later part of the pile-dwelling, dated to c. 3100 BC.

The second ash chronology was composed with wood documented in 2007, at excavation of trench 3. Six measured samples (**SG07-**1045, 1047, 1049, 1056, 1058, 1064) from 2007 were mutually cross-dated and combined into the SG-FRSP2 chronology. Samples, gained during the rest of research years, were cross-dated and incorporated into it, so that the chronology is composed of 12 samples altogether. Samples originate from trench 3 and ditch 13, on the utmost western part and in ditches 1, 3, 4, and 5 on the eastern part of the settlement.

The SG-FRSP2 chronology is not radiocarbon dated, however, it was cross-dated with the SG-QUSP1

[7] See Chapter 6 in this monograph.



Sl. 7.4: Vsi koli iz jarkov in sond – k jarku 1 so prišteti tudi koli iz sond 1 in 2, k jarku 13 pa koli iz sonde 3 –, razvrščeni po drevesnih vrstah.
Šifrant kratic: FRSP (jesen/*Fraxinus* sp.), QUSP (hrast/*Quercus* sp.), PPSP (topol/*Populus* sp.), FASY (bukev/*Fagus sylvatica*), ALGL (jelša/*Alnus glutinosa*), ACSP (javor/*Acer* sp.), SASP (vrba/*Salix* sp.), COAV (leska/*Corylus avellana*), ABAL (jelka/*Abies alba)*, CPBE (gaber/*Carpinus betulus)*, INID (neidentificirano).
Fig. 7.4: All piles from ditches and trenches – ditch 1 also includes piles from trenches 1 and 2, ditch 13 also includes piles from trench 3 – sorted according to tree species.
Abbreviations used: FRSP (ash/*Fraxinus* sp.), QUSP (oak/*Quercus* sp.), PPSP (poplar/*Populus* sp.), FASY (beech/*Fagus sylvatica*), ALGL (alder/*Alnus glutinosa*), ACSP (maple/*Acer* sp.), SASP (willow/*Salix* sp.), COAV (hazel/*Corylus avellana*), ABAL (fir/*Abies alba*), CPBE (common hornbeam/*Carpinus betulus*), INID (unidentified).

nus glutinosa), javorja (*Acer* sp.), vrbe (*Salix* sp.), leske (*Corylus avellana*), jelke (*Abies alba*) in gabra (*Carpinus betulus*) (*tab. 7.1*).

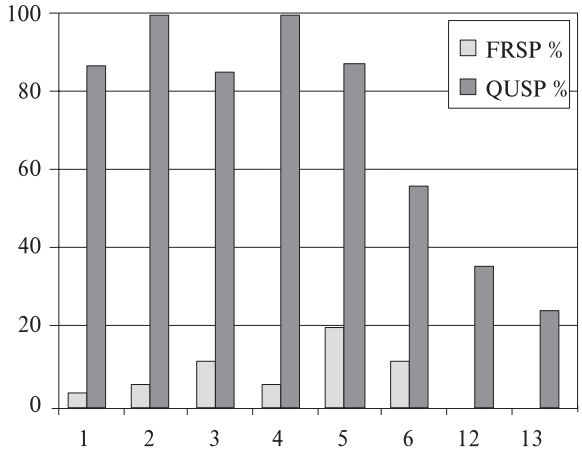
Jesenove kole najdemo v vseh jarkih. Zdi se, da jih je sorazmerno več na vzhodnem delu naselbine (*sl. 7.4*).

Med jesenovimi koli jih je manj kot 10 % klanih. V nekoliko večjem številu jih najdemo edino v jarku 5 (odseki 2–12), v jarku 3 (odseki 59–63) in v jarku 1 (odseki 132–136) (glej *sl. 7.5*).

Druga najpogostejša lesna vrsta na kolišču je hrastovina. Tudi hrastovi koli so razporejeni po celotni naselbini. Z največjim deležem jih najdemo na zahodnem delu (*sl. 7.4*). Med hrastovimi koli jih je približno 65 % klanih. V naselbini so razporejeni zelo različno. Klani oak chronology (relative date, right, 175, OVL 119, t_{BP} 4.8, GLK 61*), which indicates that the ash piles, listed above, were probably driven into the ground simultaneously with the oak ones, towards the end of building activities of the SG-QUSP1 chronology, in c. 3111 BC.

7.1.2.3 SELECTION OF WOOD AND BUILDING ACTIVITIES

As mentioned above, different species of wood were used for foundation piles at Stare gmajne. They mostly used ash (*Fraxinus* sp.) and oak (*Quercus* sp.), but also



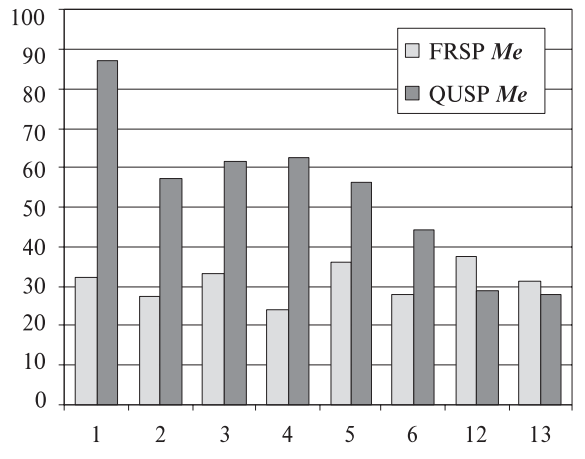
Sl. 7.5: Delež klanih jesenovih (FRSP) in hrastovih (QUSP) kolov v % po jarkih in sondah – k jarku 1 so prišteti tudi koli iz sond 1 in 2, k jarku 13 pa koli iz sonde 3.
Fig. 7.5: Percentage of cleaved ash (FRSP) and oak (QUSP) piles in ditches and trenches – ditch 1 also includes piles from trenches 1 and 2, ditch 13 also includes piles from trench 3.

hrastovi koli prevladujejo v jarkih na vzhodu naselbine, kjer jih najdemo z deleži od 85 % do 100 % v jarkih od 1–5 in 57 % v jarku 6. Veliko manj pa jih je na zahodu, kjer se v jarku 13 s sondo 3 in jarku 12 pojavljajo samo s 27 do 37 % med vsemi hrastovimi koli (*sl. 7.5*).

Približno 20 % vseh kolov pripada ostalim drevesnim vrstam. Tudi slednji so v glavnem razporejeni po celotni naselbini. Vseeno pa je med njimi opaziti grupiranje po posameznih območjih, kjer se omembe vredna količina jelševih kolov (12 % delež) pojavlja v jarku 13, odseki 27–31, 34–35 in 37, ter skupinica treh jelševih kolov v jarku 6, odsek 34, in dva jelševa kola v jarku 5, odsek 15. Večja skupina kolov iz lesa topolov (*Populus*) se pojavlja v pasu od odsekov 38–40 v jarku 4, 58–60 v jarku 3, 89–94 v jarku 2, do odsekov 118–120 v jarku 1. Naleteli smo tudi na 5 jelovih kolov, vsi so iz jarka 5, odsek 7 (glej *sl. 7.4*).

Analizirali smo tudi število branik glede na drevesno vrsto. Mediana pri jesenovih kolih je manj kot 32, kar velja za vse jarke in sonde. Podobno je tudi pri večini ostalih drevesnih vrst, kjer mediana števila branik dosega naslednje vrednosti: *Populus* (*Me* = 15; N = 48), *Alnus* (*Me* = 21; N = 28), *Fagus* (*Me* = 23; N = 31), *Acer* (*Me* = 31; N = 27), *Salix* (*Me* = 19; N = 20) in *Abies* (*Me* = 33; N = 5). Slika je nekoliko drugačna pri hrastu, kjer opazimo razlike po jarkih in sondah: hrastovi koli z največ branikami so iz jarka 1 in sonde 2, *Me* = 87, jarkov od 2 do 5, *Me* = 59,5, jarka 6, kjer je *Me* = 44,5. V jarkih 12, 13 in sondi 3 znaša vrednost mediane števila branik 28,5 (*sl. 7.6*).

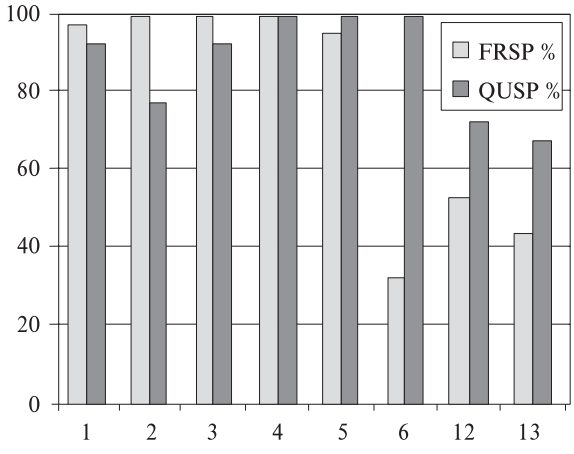
Hrastov les ima med uporabljenimi lesnimi vrstami edini obarvano jedrovino, ki je naravno odporna proti biološkemu razkroju (glivam in insektom), zato bi bilo



Sl. 7.6: Mediana (*Me*) števila branik pri jesenovih (FRSP; N = 405) in hrastovih (QUSP; N = 327) kolih po jarkih in sondah – k jarku 1 so prišteti tudi koli iz sond 1 in 2, k jarku 13 pa koli iz sonde 3.
Število v analizo vključenih vzorcev po jarkih in sondah:
1 (jarek 1, sondi 1 in 2)**:** N = 147 (FRSP); N = 87 (QUSP).
2 (jarek 2)**:** N = 18 (FRSP); N = 9 (QUSP).
3 (jarek 3)**:** N = 69 (FRSP); N = 56 (QUSP).
4 (jarek 4)**:** N = 32 (FRSP); N = 20 (QUSP).
5 (jarek 5)**:** N = 47 (FRSP); N = 16 (QUSP).
6 (jarek 6)**:** N = 43 (FRSP); N = 14 (QUSP).
12 (jarek 12)**:** N = 13 (FRSP); N = 42 (QUSP).
13 (jarek 13 in sonda 3)**:** N = 36 (FRSP); N = 83 (QUSP).
Fig. 7.6: Median (*Me*) of number of annual rings at ash (FRSP; N = 405) and oak (QUSP; N = 327) piles according to ditches and trenches – ditch 1 also includes piles from trenches 1 and 2, ditch 13 also includes piles from trench 3.
Number of samples, used for the analysis, according to ditches and trenches:
1 (ditch 1, trenches 1 and 2)**:** N = 147 (FRSP); N = 87 (QUSP).
2 (ditch 2)**:** N = 18 (FRSP); N = 9 (QUSP).
3 (ditch 3)**:** N = 69 (FRSP); N = 56 (QUSP).
4 (ditch 4)**:** N = 32 (FRSP); N = 20 (QUSP).
5 (ditch 5)**:** N = 47 (FRSP); N = 16 (QUSP).
6 (ditch 6)**:** N = 43 (FRSP); N = 14 (QUSP).
12 (ditch 12)**:** N = 13 (FRSP); N = 42 (QUSP).
13 (ditch 13 and trench 3)**:** N = 36 (FRSP); N = 83 (QUSP).

poplar (*Populus* sp.), beech (*Fagus sylvatica*), alder (*Alnus glutinosa*), maple (*Acer* sp.), willow (*Salix* sp.), hazel (*Corylus avellana*), fir (*Abies alba*) and wood of common hornbeam (*Carpinus betulus*) (*Tab. 7.1*).

Ash piles were found in all ditches. It seems that they are more common on the eastern part of the settlement (*Fig. 7.4*).



Sl. 7.7: Delež jesenovih in hrastovih kolov v % z ohranjeno zadnjo braniko ali s pretežno ohranjeno beljavo – k jarku 1 so prišteti tudi koli iz sond 1 in 2, k jarku 13 pa koli iz sonde 3.
Fig. 7.7: Percentage of ash and oak piles with preserved last annual ring or with almost entirely preserved sapwood – ditch 1 also includes piles from trenches 1 and 2, ditch 13 also includes piles from trench 3.

smiselno pričakovati, da so za pilote najprej uporabili predvsem hrastov les, šele ko je tega zmanjkalo, pa so posegli po drugih vrstah. Jesenov les je načeloma za kole manj primeren, ker ni naravno odporen. Jesena je bilo v okolici kolišč verjetno veliko, ker bolje uspeva na vlažnejših rastiščih (to je bliže stoječi vodi) kot hrast, poleg tega se tudi dobro pomlajuje na panju. To pomeni, da kmalu po poseku dreves iz panjev odženejo poganjki, iz katerih v nekaj letih zraste skupina novih dreves. Taka drevesa so premer 10 cm lahko dosegla že po 10 letih, kar je omogočalo relativno kratek čas med dvema sečnjama v istem sestoju.

Razlog za manjše število branik na zahodnem delu naselbine pri hrastovih in jesenovih kolih je torej iskati v tem, da so sekali mlajša drevesa s primernimi premeri (okoli 10 cm) za uporabo za nosilne kole. P. Pétrequin[8] ter Pétrequin et al.[9] so na primeru velikega števila dendrokronološko datiranih kolov na koliščih v francoski Juri ugotovili, da so za kole najprej sekali drevesa ugodnih premerov (okoli 10 cm), ki so bila praviloma mlajša in hitreje rastoča. Ko je teh zmanjkalo, pa so bili prisiljeni uporabljati tudi drevesa večjih premerov (npr. nad 15 cm). Za posek in spravilo večjih dreves je bilo treba uporabiti drugačno tehnologijo, debla velikih dreves pa so morali razklati, da so jih z razpoložljivo tehnologijo lahko zabili v tla.[10] Nam teh teorij zaradi velikega števila nedatiranih zaporedij širin branik še ni uspelo preveriti. Večji delež kolov iz neklanih mlajših debel na zahodu naselbine potrjuje, da so v tem delu naselbine hrastov pa tudi jesenov les posekali v mlajšem gozdu kot za gradnjo

[8] 1996.
[9] 1998.
[10] Eberschweiler, Riethmann 1998.

Less than 10 % of ash piles are cleaved. They are more frequent only in ditch 5 (sections 2–12), ditch 3 (sections 59–63) and in ditch 1 (sections 132–136) (see *Fig. 7.5*).

The second most frequent wood species is oak. Oak piles were distributed over the entire settlement. The highest percent of them occur on the western part of the settlement (*Fig. 7.4*). Around 65 % of oak piles were cleaved. Their distribution is not consistent. Cleaved oak piles prevail in ditches on the eastern part of the settlement. They occur in 85 % to 100 % in ditches 1–5 and 57 % in ditch 6. A lesser amount is present on the western part, with only 27 to 37 % of oak piles in ditch 13 with trench 3 and in ditch 12 (*Fig. 7.5*).

Around 20 % of piles belong to other tree species. They are distributed over the entire settlement. We can notice some individual clusters, e.g. a cluster of alder piles (12 %) in ditch 13, sections 27–31, 34–35 and 37, and a cluster of three alder piles in ditch 6, section 34, and two alder piles in ditch 5, section 15. A cluster of poplar (*Populus*) piles occurs in a strip from sections 38–40 in ditch 4, 58–60 in ditch 3, 89–94 in ditch 2, to sections 118–120 in ditch 1. We also found 5 fir (*Abies*) piles in ditch 5, section 7 (see *Fig. 7.4*).

We also analysed the tree-ring number of particular tree species. Ash piles median is less than 32, which applies to all ditches and trenches. Similar is also true for the majority of other tree species, where median of number of annual rings is as follows: *Populus* (*Me* = 15; N = 48), *Alnus* (*Me* = 21; N = 28), *Fagus* (*Me* = 23; N = 31), *Acer* (*Me* = 31; N = 27), *Salix* (*Me* = 19; N = 20) and *Abies* (*Me* = 33; N = 5). Oak is somewhat different. Namely, we noticed differences in ditches and trenches: oak piles with the most annual rings are present in ditch 1 and trench 2, *Me* = 87, in ditches 2 to 5, *Me* = 59.5, and median in ditch 6 is 44.5. In ditches 12, 13 and in trench 3, median of tree-ring number amounts to 28.5 (*Fig. 7.6*).

Oak wood is the only used species with coloured heartwood, which is naturally resistant against biological decay (fungi and insects). That is why it would be reasonable to expect that mostly oak was used for piles at first. When the pile dwellers ran out of oak, they started to use other species. Ash wood is less suitable for piles as it is not durable. Ash was probably growing in large amounts close to pile-dwellings, because it can grow in habitats that are temporarily flooded, and because of a good regeneration (coppice). To be precise, soon after the felling of trees, new shoots sprout from the stumps and they represent new trees that grow rapidly. Such trees could achieve diameters of 10 cm in 10 years, which was allowing relatively short time span between two felling activities in the same stand.

The reason for smaller number of annual rings in the piles on the western part of the settlement is therefore felling and using of younger trees with suitable diameters

na vzhodnem delu naselbine. V smislu zgoraj citiranih referenc bi tudi to posredno lahko nakazovalo, da je zahodni del naselbine starejši, na kar nakazujejo tudi ugotovitve dendrokronoloških raziskav.

Na splošno lahko rečemo, da so koliščarji na Starih gmajnah za nosilne kole uporabljali les, ki je bil posekan v mladem gozdu, oz. so za to uporabili mlada drevesa, kar je tudi olajšalo transport in pripravo kolov. Zdi pa se tudi, da so bili sčasoma na vzhodnem delu naselbine prisiljeni poseči tudi po debelejših, v glavnem starejših hrastovih drevesih, v posameznih obdobjih pa tudi po drugih sicer manj primernih vrstah lesa.

7.1.2.3.1 Gradbene aktivnosti

Ker smo raziskali razmeroma veliko območje in ker nam je uspelo sinhronizirati večino hrastovih kolov ter zaporedja širin branik združiti v eno kronologijo, nam podatki omogočajo tudi rekonstrukcijo gradbenih aktivnosti na Starih gmajnah. Veliko omejitev pri tem pa predstavlja to, da les izvira le iz jarkov, ki sekajo kolišče, kar onemogoča prepoznavanje tlorisov konstrukcij na terenu. Kot kaže manjša skupina sinhroniziranih hrastovih kolov, je bila najstarejša poselitev verjetno na območju jarka 13 in sonde 3 ter jarka 12.

Najboljšo rekonstrukcijo omogoča les, posekan po letu 3160 pr. Kr., ki sestavlja glavnino hrastove kronologijo SG-QUSP1, ki je na tem delu podprta z več kot 100 vzorci, razporejenimi po skoraj celotni naselbini. Največ jih je na vzhodnem delu, veliko manj na zahodu (*sl. 7.8*).

Omenjena kronologija kaže, da se je poselitev na Starih gmajnah začela malo pred letom 3160 pr. Kr.: največ kolov, posekanih v tem obdobju, najdemo v jarkih 1 in 3 ter po enega v jarkih 5, 6 in 13.

Čez približno 10 let, okoli 3151 do 3148 pr. Kr., sledi obdobje intenzivnejše gradbene aktivnosti. Objekte, ki so bili postavljeni v tem času, najdemo v jarku 4 na območju odsekov 38–40 ter na območju med jarkom 4, odsek 46, in jarkom 3, odseka 69–70. Posamezni koli pa kažejo na gradbeno aktivnost tudi na območju sonde 2 ter jarkov 1, 5 in 6.

V obdobju po letu 3144 pr. Kr. sledi še ena intenzivnejša faza gradbene aktivnosti, kot kaže les, posekan okoli let 3144 do 3138 pr. Kr. Objekte, ki so bili postavljeni v tem času, najdemo v jarku 3 na območju odsekov 60 do 63 in v sosednjem jarku 4, odsek 39, ter v jarku 2, odsek 95. V jarku 3 je zaznati gradbeno aktivnost tudi nekoliko južneje na območju odsekov 69 in 70. Prav tako ocenjujemo, da se je v tem času gradilo tudi na območju sonde 2 in jarka 1 ter na območju jarka 5, odsek 3, in jarka 13, odsek 30.

V obdobju okoli let med 3133 in 3130 pr. Kr. so postavljali objekte na območju jarka 5, odseki 9, 11 in 12, in jarka 6, odsek 29. Gradbeno aktivnost pa je

(c. 10 cm). Pétrequin[8] and Pétrequin et al.[9] studied a large number of dendrochronologically dated piles from pile-dwellings in the French Jura, and discovered that trees with diameters, suitable for piles (c. 10 cm) were usually felled first. These trees were normally younger and were growing fast. When the dwellers ran out of such trees, they were forced to use trees with larger diameters (e.g. above 15 cm). Different technology had to be used for removal and skidding of larger trees. Trunks of large trees had to be cleaved in order to be driven into the ground with then available technology.[10] We could not yet verify if such practices were used in the Ljubljansko barje too because in our case most of the piles are undated due to limited amount of tree-rings. Large percentage of piles from the uncleaved younger trunks from the western part of the settlement is confirming that oak and ash wood was felled in younger forest, in contrast to the eastern part of the settlement. This, together with the references quoted above, could be an indirect hint that the western part of the settlement is somewhat older; dendrochronological researches indicate the same.

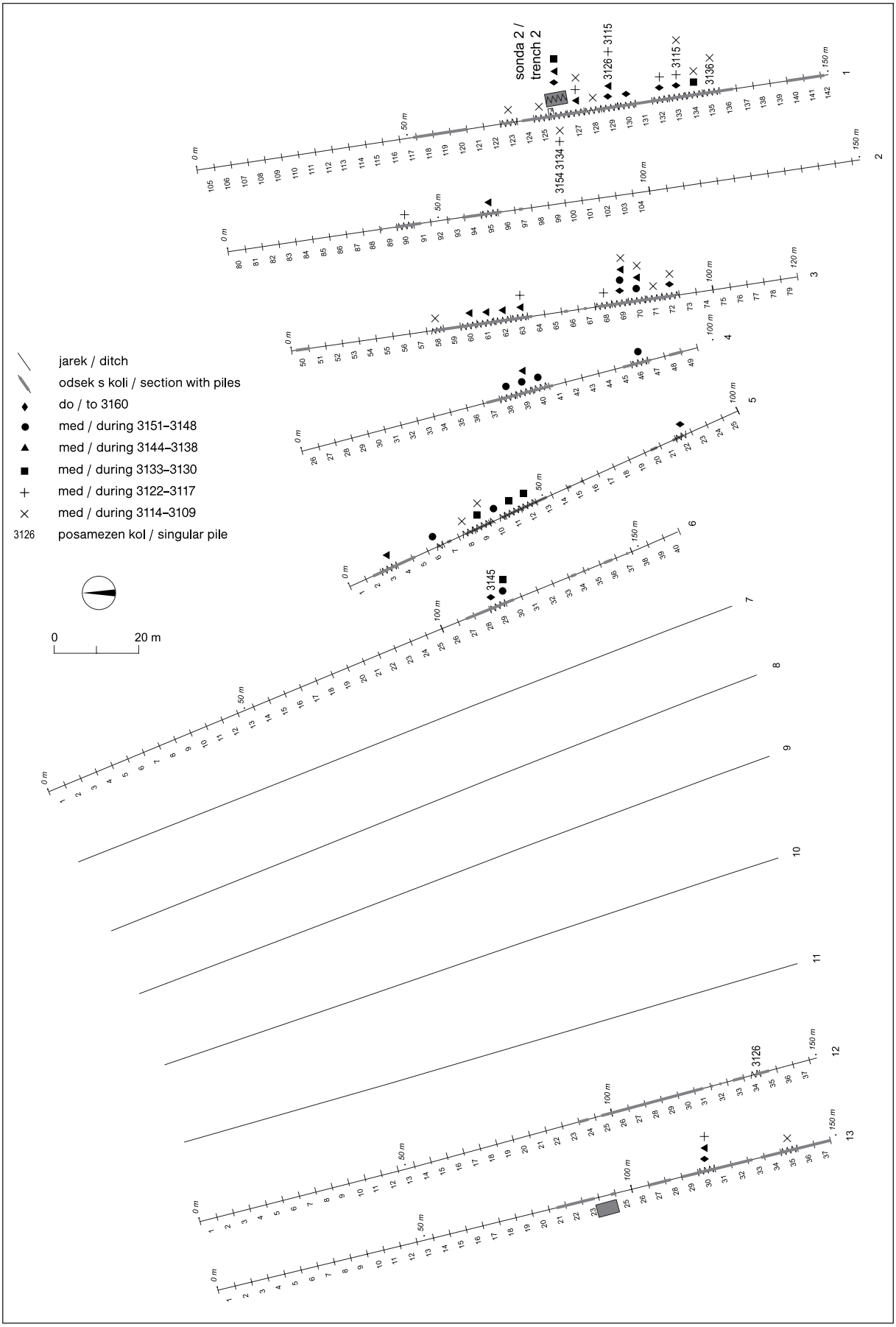
We can say that pile-dwellers from Stare gmajne used wood from young forest or used young trees for foundation piles, which also eased transport and preparation of piles. It also appears that, at the eastern part of the settlement, they later used larger, mainly older oak trees and sometimes also other, less suitable wood species.

7.1.2.3.1 Building activities

As we researched a comparatively large area and we managed to cross-date the majority of oak piles and to incorporate tree-ring series to a single chronology, we can also reconstruct building activities at Stare gmajne. However, a large restraint for the reconstruction exists. Namely, wood only originates from ditches, which cut the pile-dwelling. This makes recognizing of ground plans of constructions difficult or impossible. A small group of cross-dated oak piles indicates that the earliest settlement probably existed in ditch 13 and trench 3, and in ditch 12.

[8] 1996.
[9] 1998.
[10] Eberschweiler, Reithmann 1998.

Sl. 7.8: Razporeditev datiranih kolov mlajšega dela hrastove kronologije SG-QUSP1. Številke označujejo kalibrirana koledarska leta pred Kristusom, pri katerih je treba upoštevati standardno napako ± 12 let. Risba: T. Korošec.
Fig. 7.8: Distribution of dated piles in the later part of the SG-QUSP1 oak chronology. The numbers mark calibrated calendar years BC, with a standard error of ± 12 years. Drawn by: T. Korošec.


sonda 2 / trench 2
3126+3115
+3115
3136
3154 3134 +
jarek / ditch
odsek s koli / section with piles
do / to 3160
med / during 3151–3148
med / during 3144–3138
med / during 3133–3130
med / during 3122–3117
med / during 3114–3109
3126 posamezen kol / singular pile
0 20 m
3145
3126

zaznati v sondi 2 in njeni bližini v jarku 1 ter odsekih 134 in 135.

Gradbena aktivnost okoli leta 3126 pr. Kr. je ugotovljena v jarku 1, odsek 129, ter v jarku 12, odsek 34. Na aktivnosti med letoma 3122 in 3117 pr. Kr. lahko sklepamo po kolih iz jarka 1, odseka 132 in 133, najizraziteje pa iz odsekov 126 in 127, in na podlagi kolov iz jarkov 2, odsek 90, in 3, odseka 63 in 68.

V obdobju po letu 3117 pr. Kr. je zaznati gradbeno aktivnost v jarku 1, v odsekih 129 in 133. Med letoma 3114 in 3109 pr. Kr. je zaznavana gradbena aktivnost v jarku 13, odsek 35. Nove objekte so verjetno postavljali v jarku 5, odseka 8 in 9, v jarku 3, odseki 69 do 72, in v jarku 1 v bližini sonde 2 ter v odsekih 133 do 135. Domnevamo, da koli, posekani v tem obdobju, kažejo na zadnje obdobje gradbenih aktivnosti na kolišču Stare gmajne.

Skratka, v okviru mlajšega dela hrastove kronologije SG-QUSP1 lahko sledimo gradbenim aktivnostim, ki so trajale dobrih 50 let in se končale z letom 3109 pr. Kr. To je okvirno čas, ko je na Starih gmajnah najverjetneje živela mlajša naselbina. Zahodni del pa je bil, sicer krajše obdobje, zelo verjetno poseljen že po koncu aktivnosti na Spodnjem mostišču, torej po letu 3351 pr. Kr.

Glede na razpored in razpoložljive datacije jesenovih kolov domnevamo, da so ves čas po celotnem kolišču hkrati s hrastovim lesom sekali in uporabljali tudi jesenovega.

7.2 BLATNA BREZOVICA

Koliščarska naselbina Blatna Brezovica leži na jugozahodu Ljubljanskega barja med istoimenskim osamelcem in reko Ljubljanico, nasproti ji stojita koliščarski naselbini Hočevarica in Stare Gmajne. Naselbina je bila odkrita med drugo svetovno vojno. Prvo in doslej najobsežnejše arheološko izkopavanje pa je potekalo leta 1953, ko je J. Korošec na parceli št. 408 k. o. Blatna Brezovica zastavil 304 m^2 veliko izkopavališče. Pri izkopavanju je pionirsko sodeloval tudi paleobotanik A. Šercelj, ki je determiniral koliščarski les in ugotovil, da z 80 % prevladuje kostanj, nato sledijo hrast z 10 %, breza, jelša, bukev itn.[11] Kasneje so ugotovili, da je bil kostanjev les v resnici jesenov, dendrokronoloških raziskav pa takrat še niso izvajali.

Leta 2003 je v maju, oktobru in novembru ekipa Inštituta za arheologijo ZRC SAZU v okviru temeljnega raziskovalnega projekta "Arheološke in dendrokronološke raziskave na Ljubljanskem barju" (J6-3075) na Blatni Brezovici na območju Koroščevega izkopavališča zastavila dve sondi z namenom, da pridobi les za dendrokronološke raziskave.[12] V nadaljevanju opisujemo raziskave lesa.

[11] Šercelj 1955, 142.

[12] Glej poglavje 5 v tem zborniku.

Wood, felled after 3160 BC, enables the best reconstruction. It forms the main body of the SG-QUSP1 oak chronology, with more than 100 samples from this area, which are dispersed almost over the entire settlement. The eastern part contains the most, while there are much less on the western part (*Fig. 7.8*).

The mentioned chronology indicates that the settlement of Stare gmajne was established just before 3160 BC: the most piles, felled in this period come from ditches 1 and 3, while ditches 5, 6 and 13 contained one example each.

After c. 10 years, during c. 3151 to 3148 BC, a period of more intensive building activity follows. Constructions, dating to this period, were present in sections 38–40 of ditch 4, and in the area between ditch 4, section 46 and ditch 3, sections 69–70. Individual piles also show building activity in trench 2 and ditches 1, 5 and 6.

Another intense building phase follows in the period after 3144 BC, particularly with the usage of wood felled in c. 3144 to 3138 BC. Constructions, dating to this period, were found in ditch 3, sections 60 to 63, in adjoining ditch 4, section 39 and in ditch 2, section 95. Building activity in ditch 3 spreads southwards, to sections 69 and 70. We also assume that building activity was also performed in trench 2, ditch 1, in ditch 5, section 3, and in ditch 13, section 30.

In the period between c. 3133 and 3130 BC, construction work was carried out in ditch 5, sections 9, 11 and 12, and ditch 6, section 29. Building activity is also seen in trench 2, ditch 1 and sections 134–135.

Building activity in c. 3126 BC was discovered in ditch 1, section 129 and in ditch 12, section 34. Activities between 3122 and 3117 BC are indicated by piles from ditch 1, sections 132–133, the most explicitly from sections 126 and 127, and by piles from ditch 2, section 90 and ditch 3, sections 63 and 68.

After 3117 BC, building activity can be seen in ditch 1, sections 129 and 133. Between 3114 and 3109 BC building activities were performed in ditch 13, section 35. New constructions were probably built in ditch 5, sections 8 and 9, in ditch 3, sections 69 to 72 and in ditch 1, close to trench 2, and in sections 133 to 135. We suppose that piles, felled in this period, indicate the last period of building activities at the pile-dwelling Stare gmajne.

To summarise, the later part of the SG-QUSP1 oak chronology enables us to follow building activities that lasted more than 50 years and ended in 3109 BC. This is, in general, most probably period of the later settlement on Stare gmajne. Western part of the site was probably, for a shorter period, populated as soon as the activities on Spodnje mostišče ended, i.e. after 3351 BC.

Considering the ash pile disposition and available dates, we suppose that pile-dwellers felled and used oak and ash over the entire pile-dwelling simultaneously.

7.2.1 DENDROKRONOLOŠKE RAZISKAVE

7.2.1.1 VZORČENJE LESA

Iz načrta (*sl. 7.9*) je razvidno, da so bili koli vzeti z območja, ki je obsegalo približno 50 m^2. Glede na Koroščev načrt iz leta 1953[13] sklepamo, da sta bili naši izkopavališči zastavljeni na vzhodnem delu Koroščevega izkopavališča.[14] V obeh izkopavanjih je bilo vzetih in raziskanih skupno 170 vzorcev navpičnih kolov.

7.2.1.2 PRIPRAVA IN IDENTIFIKACIJA LESA

Za dendrokronološke raziskave je bil odvzet les vseh ohranjenih elementov ne glede na obliko, premer in lesno vrsto. Najdbam lesa smo najprej izmerili natančne koordinate in nato odžagali 10–20 cm dolg kos, ki smo ga takoj po odvzemu izmerili, označili z identifikacijsko številko in ga zalitega z vodo shranili v nepredušno zaprti polietilenski vrečki.

Zbrane vzorce smo odpeljali na Oddelek za lesarstvo, kjer so jih raziskali po ustaljeni metodi.[15]

Postopek merjenja je potekal podobno kot pri lesu s Starih gmajn.[16] Dendrokronološke meritve smo opravili samo na vzorcih hrasta in jesena, ki so imeli vsaj 45 branik (*tab. 7.6*).

7.2.2 REZULTATI

Največ je bilo hrastovega lesa, ki je zastopan kar z 51 % vzorcev, sledil mu je jesen z 32 % vzorcev (*tab. 7.6*). Približno 15 % vzorcev je pripadalo drugim vrstam, med katerimi je prevladoval javor (*Acer*).

Za merjenje je bilo primernih le 28 % vzorcev, z vsaj 45 branikami, sinhronizirali oz. relativno datirali pa smo le 7 % vzorcev, kar je precej manj kot npr. pri Starih gmajnah in drugih koliščarskih naselbinah.[17] To morda nakazuje, da je bil izbor lesa osiromašen zaradi izkopavanj pred več kot 50 leti.

Od 31 merjenih hrastovih vzorcev smo jih sinhronizirali samo 13 (**BB03-**29, 46, 48, 68, 84, 110, 114, 118, 125, 129, 130, 133 in 167) ter sestavili 87 let dolgo hrastovo kronologijo. Ker imajo malo branik in veliko rastnih anomalij, statistično značilna sinhronizacija ni bila možna z nobeno od kronologij z Ljubljanskega barja. Rastne anomalije kažejo na močne antropogene vplive v sestojih, kjer je bil les posekan.

[13] Koršec 1963, pril. 10.
[14] Glej poglavje 5.2.2.1 v tem zborniku: *sl. 5.4.*
[15] Glej poglavje 7.1.1.2 v tem prispevku.
[16] Glej poglavje 7.1.1.3 v tem prispevku.
[17] Glej *tab. 7.2* in Čufar, Velušček 2004, 267–269.

7.2 BLATNA BREZOVICA

The pile-dwelling settlement Blatna Brezovica is located on the south-western side of the Ljubljansko barje, between an eponymous isolated hill and the Ljubljanica River; pile-dwelling settlements of Hočevarica and Stare gmajne are located opposite to it. The settlement was discovered during the 2nd World War. In 1953, the first and the most extensive archaeological excavation so far was carried out. J. Korošec opened a 304 m^2 large excavation site on plot no. 408 in the Blatna Brezovica cadastral registry. A pioneer collaboration with a palaeobotanist A. Šercelj was performed at the excavation. Šercelj determined pile-dwelling wood and discovered, that chestnut prevails with 80 %, followed by oak with 10 %, birch, alder, beech etc.[11] It was revealed afterwards, that chestnut wood is actually ash. Dendrochronological researches were not performed at that time yet.

In 2003, in May, October and November, a team of the Institute of Archaeology ZRC SAZU, opened two trenches at Blatna Brezovica, inside the area of the site dug by Korošec. This was done as a part of the "Archaeological and Dendrochronological Research in the Ljubljana Moor" (J6-3075) research project, with the intention to gain wood for dendrochronological researches.[12] Investigations of wood are presented below.

7.2.1 DENDROCHRONOLOGICAL RESEARCHES

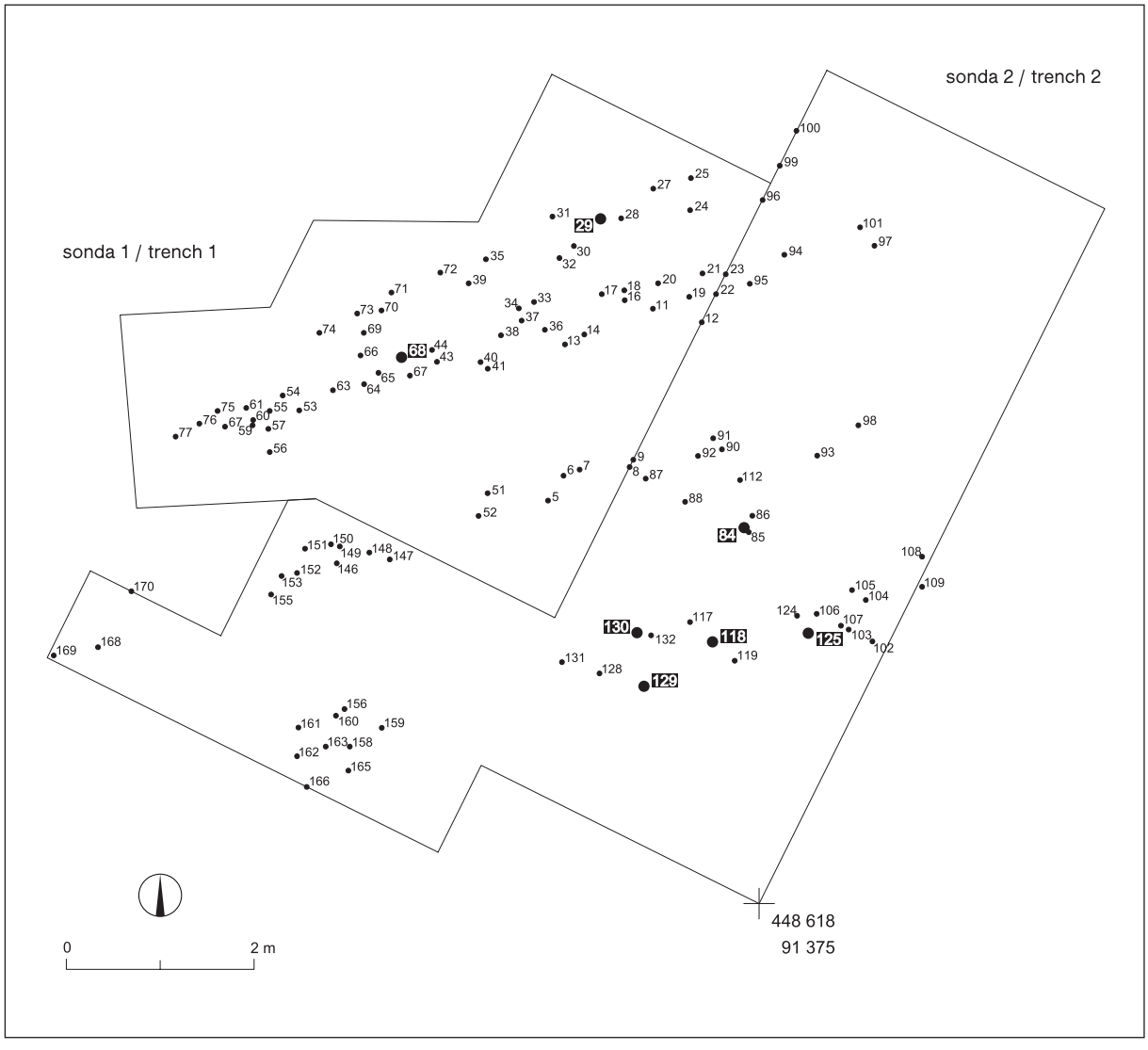
7.2.1.1 SAMPLING OF WOOD

As we can see from the plan (*Fig. 7.9*), piles were taken from the area of c. 50 m^2. We assume, considering the Korošec's plan from 1953,[13] that our excavation sites were opened on the eastern part of the Korošec's excavation site.[14] Altogether, 170 samples of vertical piles were taken and investigated.

7.2.1.2 THE PREPARATION AND IDENTIFICATION OF WOOD

Wood for dendrochronological researches was taken from all preserved elements, regardless of form, diameter and wood species. We first measured accurate coordinates of all wooden finds and then sawed off 10–20 cm long piece, measured it immediately after sawing, marked it with an identification number and stored in a hermetically closed polyethylene bag, filled with water.

[11] Šercelj 1955, 142.
[12] See Chapter 5 in this monograph.
[13] Korošec 1963, appendix 10.
[14] See Chapter 5.2.2.1 in this monograph: *Fig: 5.4.*



Sl. 7.9: Blatna Brezovica – sondi 1 in 2 iz leta 2003 z označenimi navpičnimi koli; poudarjeni so sinhronizirani koli. Risba: T. Korošec.
Fig. 7.9: Blatna Brezovica – trenches 1 and 2 from 2003 with marked vertical piles; cross-dated piles shown in bold. Drawn by: T. Korošec.

Glede na radiokarbonsko datiranje vzorca kola BB03-48 (4499 ± 21 uncal BP) (*tab. 7.7*) in potek kronologije smo s pomočjo metode "wiggle-matching" ocenili leto zadnje branike v kronologiji BB-QUSP1 na 3071 ± 12 pr. Kr.

Tako sklepamo, da je naselbina nekoliko mlajša kot Stare gmajne oz. da je bil posek lesa raziskanih vzorcev z Blatne Brezovice opravljen po poseku najmlajših hrastov s Starih gmajn. Skorajšno sočasnost pa nakazuje tudi analiza arheoloških najdb, predvsem keramike.[18]

The selected samples were taken to the Department of Wood Science and Technology, where they were prepared using standard procedure.[15]

Measuring procedure was similar as the one used on wood from Stare gmajne.[16] Dendrochronological measurements were only done on oak and ash samples with at least 45 annual rings (*Tab. 7.6*).

[18] Glej poglavje 1.3 v tem zborniku.

[15] See Chapter 7.1.1.2 in this article.
[16] See Chapter 7.1.1.3 in this article.

Tab. 7.6: Število vzorcev po vrstah lesa ter število in deleži dendrokronološko merjenih in sinhroniziranih vzorcev.
Tab. 7.6: The number of samples according to wood species and number and percentage of dendrochronologically measured and cross-dated samples.

Vrsta lesa Wood species	Število Number	Delež (%)* Percentage	Merjen (št.) Measured (no.)	Merjen (%)* Measured (%)*	Sinhroniziran (št.) Cross-dated (no.)	Sinhroniziran (%)* Cross-dated (%)*
Acer sp.	15	9	0			
Alnus glutinosa	3	2	0			
Corylus avellana	4	2	0			
Fagus sylvatica	3	2	0			
Fraxinus sp.	55	32	19	11	0	0
Populus sp.	1	1	0			
Quercus sp.	87	51	31	17	13	7
Salix sp.	2	1	0			
SKUPAJ TOTAL	**170**	**100**	**50**	**28**	**13**	**7**

* Delež, preračunan glede na vse vzorce. / Share calculated for the entire sample population.

Tab. 7.7: Radiokarbonska datacija vzorca kola z Blatne Brezovice. Datiranje je bilo opravljeno v laboratoriju na Heidelberger Akademie der Wissenschaften, Radiometrische Altersbestimmung von Wasser und Sedimenten.
Tab. 7.7: Radiocarbon dates of sample piles from Blatna Brezovica. Dating was performed in the laboratory of the Heidelberger Akademie der Wissenschaften, Radiometrische Altersbestimmung von Wasser und Sedimenten.

Kol št. Pile no.	Lab. št. Lab. no.	Drevesna vrsta Wood species	Srednja branika Mid tree ring	^{14}C-age BP
BB03-48	Hd-24036	*Quercus*	181	4499 ± 21

7.3 SKLEP

V prispevku smo analizirali arheološki les s koliščarske naselbine Stare gmajne na Ljubljanskem barju in dobljene rezultate primerjali z raziskavami lesa z naselbine Blatna Brezovica.

Na podlagi arheološkega lesa s Starih gmajn, kjer med vzorci prevladujejo navpični koli, nam je uspelo sestaviti eno hrastovo in dve jesenovi kronologiji.

Največ vzorcev smo vključili v hrastovo kronologijo SG-QUSP1, kjer smo zadnjo braniko s pomočjo radiokarbonskega datiranja in metode "wiggle-matching" datirali v leto 3109 ± 12 pr. Kr. (razpon 3121–3095, 2σ, 95,4 % verjetnost). Na podlagi absolutno in relativno datiranih lesenih kolov ugotavljamo, da je bilo skoraj celotno območje (jarki 1–6, 12, 13 in sonde 1–3) intenzivno poseljeno več kot 50 let in da so se gradbene aktivnosti po hrastovi kronologiji najverjetneje končale leta 3109 pr. Kr. oz. nekaj let pozneje, kot nakazuje kronologija SG-FRSP1, ter skoraj sočasno kot na 1 km oddaljeni naselbini Veliki Otavnik Ib.[19]

Manjše število dendrokronološko datiranih vzorcev nakazuje, da je na Starih gmajnah obstajala naselbina že

[19] Glej poglavje 6 v tem zborniku.

7.2.2 RESULTS

As much as 51 % of samples were oak, followed by 32 % of ash (*Tab. 7.6*). C. 15 % of samples belonged to other species, with maple (*Acer*) prevailing.

Only 28 % of samples with at least 45 annual rings were suitable for measurements, with as little as 7 % of samples cross-dated or relatively dated, which is a lot less than e.g. at Stare gmajne and other pile-dwelling settlements.[17] This perhaps indicates that the selection of wood was impoverished because of excavations that were taking place over 50 years ago.

From 31 measured oak samples, only 13 were cross-dated (**BB03**-29, 46, 48, 68, 84, 110, 114, 118**,** 125, 129, 130, 133 and 167) and composed an 87 years long oak chronology. As the samples have few annual rings and many growth anomalies, statistically significant cross-dating was not possible with any of the chronologies from the Ljubljansko barje. Growth anomalies indicate strong anthropogenic impacts in stands, where wood was felled.

[17] See Tab. 7.2 in this article and Čufar, Velušček 2004, 267–269.

v 34. stoletju, okoli leta 3330 pr. Kr., ki je bila verjetno postavljena, potem ko so se končale gradbene aktivnosti (in poselitev) na koliščU Spodnje mostišče.

Na podlagi vzorcev, sinhroniziranih po hrastovi kronologiji Starih gmajn SG-QUSP1, smo dobili tudi vpogled, kje in kdaj so potekale gradbene aktivnosti v obdobju mlajše naselbine. Naselbina ni bila postavljena naenkrat, temveč se je njen tloris skozi čas spreminjal. Ljudje so v njej živeli na njenem vzhodnem in tudi zahodnem delu (glej *sl. 7.8*).

Natančna analiza lesa navpičnih kolov je tudi pokazala, da so koliščarji na Starih gmajnah za nosilne kole največkrat uporabili les jesena in hrasta, sledi les topola, bukve, jelše in javorja. Med navpičnimi koli so z več kot 60 % prevladovali tisti s premerom od 6 do 12 cm. Približno 20 % jih je imelo premer od 12,5 do 22 cm, manj kot 10 % pa premer od 23 do 40 cm ali pod 6 cm. Koli večjih premerov so bili praviloma klani. Za gradnjo je bil večinoma uporabljen les iz dreves z okoli 20–50 branikami (približno 60 %), manj pa les iz dreves z več kot 50 branikami (približno 30 %) ali z manj kot 20 branikami (približno 10 %).

Debla so torej v splošnem imela manj kot 50 branik, razen pri hrastu, kjer so kole iz starejših dreves v glavnem zabijali na vzhodnem delu naselbine, predvsem na območju jarka 1 in sonde 2 ter v jarkih 2–5, kjer je tudi velik delež klanih kolov. Nasprotno pa se zdi, da so na zahodu naselbine posegali po tanjših in mlajših drevesih, tudi hrastovih. Debla večjih starejših dreves so za uporabo za kole namreč morali razklati. Značilno je tudi, da so nekateri koli iz drugih vrst lesa razporejeni po skupinah, kar vsaj v nekaterih primerih morda kaže, da so jih posekali in uporabili sočasno. Slednje še posebej lahko trdimo za kole iz lesa jelše, topola in jelke. Žal rekonstrucijo otežuje to, da preučujemo samo transekte skozi naselbino in da večine kolov ne moremo datirati, ker imajo za to premalo branik.

Iz zaporedij širin branik lesa z arheološkega najdišča na Blatni Brezovici, ki je bilo že raziskano leta 1953,[20] smo sicer sestavili hrastovo kronologijo, ki pa nam je ni uspelo z zanesljivostjo sinhronizirati z nobeno drugo kronologijo z Ljubljanskega barja, medtem ko radiokarbonski datum nakazuje, da je naselbina živela v mlajšem obdobju ali že po koncu poselitve Starih gmajn.

Na koncu naj v primeru dendrokronoloških raziskav lesa s Starih gmajn in Blatne Brezovice še enkrat poudarimo, da je statistično najbolje pokrita hrastova kronologija SG-QUSP1, na podlagi katere smo ugotovili:

1. Razmeroma veliko število relativno datiranih kolov omogoča vpogled v dinamiko gradbenih aktivnosti po celotni koliščarski naselbini na Starih gmajnah.

2. S hrastovo kronologijo smo sinhronizirali kronologijo z Velikega Otavnika Ib, ki kaže, da so bila najmlajša drevesa iz kronologije VO-QUSP1 posekana

[20] Korošec 1963.

Considering the radiocarbon date of the pile BB03-48 (4499 ± 21 uncal BP) (*Tab. 7.7*), the pattern of the chronology, and with the help of the "wiggle-matching" procedure, we assessed the last annual ring date of the BB-QUSP1 chronology to be 3071 ± 12 BC.

We therefore assume that the settlement is somewhat later as the one at Stare gmajne, or, that wood felling of investigated samples from Blatna Brezovica ended after the felling of the youngest oaks from Stare gmajne. Moreover, also an analysis of archaeological finds, primarily pottery, indicates that the settlements were nearly contemporary.[18]

7.3 CONCLUSION

In this chapter, we analysed archaeological wood from the pile-dwelling settlement Stare gmajne at the Ljubljansko barje and compared the results with researches of wood from the settlement Blatna Brezovica.

Based on archaeological wood from Stare gmajne, where vertical piles prevail among samples, we succeeded to make one oak and two ash chronologies.

Most of the samples were incorporated into the SG-QUSP1 oak chronology, where the last annual ring was, with the help of radiocarbon dating and the "wiggle-matching" procedure, dated to 3109 ± 12 BC (span 3121–3095, 2σ, 95.4 % probability). Based on absolutely and relatively dated wooden piles we presume, that almost the entire area (ditches 1–6, 12, 13 and trenches 1–3) was intensely populated for more than 50 years. Moreover, the building activities, denoted by the oak chronology, most probably finished in 3109BC or a few years later, as remitted by the SG-FRSP1 chronology, and almost simultaneously with the settlement Veliki Otavnik Ib, situated 1 km away.[19]

Smaller number of dendrochronologically dated samples remit that a settlement existed at Stare gmajne in the 34th century, in around 3330 BC. It was probably constructed after the building activities (and settling) on the pile-dwelling Spodnje mostišče ended.

Based on samples, cross-dated in the Stare gmajne SG-QUSP1 oak chronology, we also obtained information on where and when the building activities in the period of the later settlement were taking place. The settlement was not constructed at once. Instead, its ground plan was changing in time. Activities within the settlement were taking place in its eastern as well as in its western part (see *Fig. 7.8*).

Precise analysis of vertical piles also showed that wood of ash and oak were used most often for foundation piles at Stare gmajne, followed by poplar, beech, alder and maple. Over 60 % of vertical piles had a diameter from 6 to 12 cm. C. 20 % had diameter from 12.5 to

[18] See Chapter 1.3 in this monograph.

[19] See Chapter 6 in this monograph.

praktično sočasno (eno leto kasneje) kot najmlajša drevesa iz SG-QUSP1.

Dendrokronološke raziskave na Starih gmajnah in Blatni Brezovici, podprte z radiokarbonskimi datacijami, so omogočile dokaj natančno absolutno datiranje obstoja obeh naselbin, ki sta mlajši od naselbin iz sredine in tretje četrtine 4. tisočletja pr. Kr. (približno od 3500 do 3330 pr. Kr.). Najstarejša med temi koliščarskimi naselbinami je Maharski prekop, nato sledijo Črešnja pri Bistri, Spodnje mostišče in Stare gmajne (starejša naselbina).

22 cm and less than 10 % a diameter from 23 to 40 cm or under 6 cm. Piles with larger diameters were generally cleaved. Wood with c. 20–50 annual rings (c. 60 %) was most regularly used for construction. Wood with more than 50 annual rings (c. 30 %) or with less than 20 annual rings (c.10 %) was not used as often.

Generally, trunks had less than 50 annual rings, except for oak, where piles from older trees were mainly driven into ground on the eastern part of the settlement, especially in ditch 1 and trench 2, and in ditches 2–5, which also have high percentage of cleaved piles. On the contrary, it seems that on the western part of the settlement, thinner and younger trees were used, also oak. Namely, they had to cleave trunks of larger older trees in order to use them as piles. Another characteristic of this site are clusters of piles from different species of wood are, which perhaps indicates that, at least in some cases, they were felled and used all at once. The latter can especially be claimed for alder, poplar and fir piles. It is, unfortunately, difficult to make reconstruction, as we are only observing transects through the settlement and as the majority of piles cannot be dated, as they do not contain enough annual rings.

From tree-ring series of wood from the site Blatna Brezovica, which was investigated in 1953,[20] we constructed one oak chronology, which we could not reliably cross-date with any other chronology from the Ljubljansko barje. Moreover, the radiocarbon date indicates that the settlement existed during the later period of the settlement Stare gmajne or after it was abandoned.

Let us emphasise once again that the SG-QUSP1 oak chronology is best replicated. The following was established based on it:

1. Comparatively large number of relatively dated piles enabled us to examine the dynamic of building activities across the entire pile-dwelling settlement Stare gmajne.

2. Oak chronology was cross-dated with the chronology from Veliki Otavnik Ib. The results indicate that the youngest trees from the VO-QUSP1 chronology fell practically at the same time (one year later) as the youngest trees from the SG-QUSP1.

Dendrochronological researches at Stare gmajne and Blatna Brezovica, supported with radiocarbon dates, gave us rather accurate absolute dating of the existence of both settlements, which existed later than settlements from the middle and third quarter of the 4th millennium BC (c. 3500 to 3330 BC). The earliest of these 4th millennium BC pile-dwelling settlements is Maharski prekop, followed by Črešnja near the Bistra, Spodnje mostišče and Stare gmajne (the earlier phase of the settlement).

[20] Korošec 1963.